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# ML401/ML402/ML403 Evaluation Platform

## *User Guide*

**UG080 (v2.5) May 24, 2006**

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# Revision History

The following table shows the revision history for this document.

| Date | Version | Revision |
|---|---|---|
| 09/24/04 | 1.0 | Initial Xilinx release. |
| 10/20/04 | 1.0.1 | Minor edits to text and figures. |
| 02/17/05 | 1.1 | Minor edits:<br>• Figure 1and Figure 4: Corrected the regulator number for the 6A SWIFT part that goes to 1.2V. Removed digital supply reference.<br>• Table 6: Corrected the GPIO LED 3 (DS6) FPGA pin number. |
| 02/28/05 | 2.0 | Renamed title from *ML401 Evaluation Platform* user guide to *ML40x Evaluation Platform* user guide.<br>Expanded document from ML401-specific to include ML401, ML402, and ML403 platforms.<br>Minor edits to text and figures. |

| Date | Version | Revision |
|---|---|---|
| 10/25/05 | 2.1 | Renamed title from *ML40x Evaluation Platform* user guide to *ML401/ML402/ML403 Evaluation Platform* user guide.<br>Technical edits:<br>• Features section: Expanded VGA output bullet items.<br>• 15. VGA Output section: Added Table 13 for the Video DAC connections.<br>Minor edits to text for clarity. |
| 11/15/05 | 2.2 | Clarified ZBT synchronous RAM size in Features section. |
| 01/13/06 | 2.3 | Minor edits:<br>• Deleted "P/N 0402337" (obsolete) from document's identification.<br>• Deleted power cord reference from Power supply bullet in Package Contents section.<br>• Typographical corrections. |
| 05/07/06 | 2.4 | Updated USB interface chip criteria in Features section. |
| 05/24/06 | 2.5 | Updated USB interface chip criteria in Features section.<br>Updated 18. ZBT Synchronous SRAM section. |

# Table of Contents


## Preface: About This Guide

**Guide Contents** . . . . . 7
**Additional Resources** . . . . . 7
**Conventions** . . . . . 7
Typographical . . . . . 7
Online Document . . . . . 8

## ML401/ML402/ML403 Evaluation Platform

**Introduction** . . . . . 9
Features . . . . . 9
Package Contents . . . . . 10
Additional Information . . . . . 10
Block Diagram . . . . . 11
**Detailed Description** . . . . . 12
1. Virtex-4 FPGA . . . . . 14
2. DDR SDRAM . . . . . 16
3. Differential Clock Input And Output With SMA Connectors . . . . . 16
4. Oscillator Sockets . . . . . 17
5. LCD Brightness and Contrast Adjustment . . . . . 17
6. DIP Switches (Active-High) . . . . . 17
7. User and Error LEDs (Active-High) . . . . . 18
8. User Push Buttons (Active-High) . . . . . 19
9. CPU Reset Button (Active-Low) . . . . . 19
10. Expansion Headers . . . . . 20
11. Stereo AC97 Audio Codec . . . . . 24
12. RS-232 Serial Port . . . . . 24
13. 16-Character x 2-Line LCD . . . . . 24
14. IIC Bus with 4-Kb EEPROM . . . . . 25
15. VGA Output . . . . . 25
16. PS/2 Mouse and Keyboard Ports . . . . . 25
17. System ACE and CompactFlash Connector . . . . . 26
18. ZBT Synchronous SRAM . . . . . 26
19. Linear Flash Chips . . . . . 27
20. Xilinx XC95144XL CPLD . . . . . 27
21. 10/100/1000 Tri-Speed Ethernet PHY . . . . . 27
22. USB Controller with Host and Peripheral Ports . . . . . 28
23. Xilinx XCF32P Platform Flash Configuration Storage Device . . . . . 28
24. JTAG Configuration Port . . . . . 28
25. Onboard Power Supplies . . . . . 29
26. AC Adapter and Input Power Switch/Jack . . . . . 29
27. Power Indicator LED . . . . . 29
28. INIT LED . . . . . 29
29. DONE LED . . . . . 30

30. Program Switch . . . . . 30
31. Configuration Address and Mode DIP Switches . . . . . 30
32. Encryption Key Battery . . . . . 30
33. Configuration Source Selector Switch . . . . . 30
**Configuration Options** . . . . . 31
JTAG (Parallel Cable IV Cable and System ACE Controller) . . . . . 31
Platform Flash Memory . . . . . 32
Linear Flash + CPLD . . . . . 32

# About This Guide

The ML401/ML402/ML403 evaluation platforms enable designers to investigate and experiment with features of the Virtex™-4 family of FPGAs. This user guide describes features and operation of the ML401, ML402, and ML403 (ML40x) evaluation platforms.

## Guide Contents

This manual contains the following chapter: "ML401/ML402/ML403 Evaluation Platform."

## Additional Resources

To find additional documentation, see the Xilinx website at:

http://www.xilinx.com/literature/index.htm.

To search the Answer Database of silicon, software, and IP questions and answers, or to create a technical support WebCase, see the Xilinx website at:

http://www.xilinx.com/support.

## Conventions

This document uses the following conventions. An example illustrates each convention.

### Typographical

The following typographical conventions are used in this document:

| Convention | Meaning or Use | Example |
|---|---|---|
| `Courier font` | Messages, prompts, and program files that the system displays | `speed grade: - 100` |
| **`Courier bold`** | Literal commands that you enter in a syntactical statement | **`ngdbuild`** *design_name* |
| **Helvetica bold** | Commands that you select from a menu | **File → Open** |
| | Keyboard shortcuts | **Ctrl+C** |

| Convention | Meaning or Use | Example |
|---|---|---|
| Italic font | Variables in a syntax statement for which you must supply values | **ngdbuild** *design_name* |
| | References to other manuals | See the *Development System Reference Guide* for more information. |
| | Emphasis in text | If a wire is drawn so that it overlaps the pin of a symbol, the two nets are *not* connected. |
| Square brackets [ ] | An optional entry or parameter. However, in bus specifications, such as **bus[7:0]**, they are required. | **ngdbuild** [*option_name*] *design_name* |
| Braces { } | A list of items from which you must choose one or more | **lowpwr =**{**on**\|**off**} |
| Vertical bar \| | Separates items in a list of choices | **lowpwr =**{**on**\|**off**} |
| Vertical ellipsis<br>.<br>.<br>. | Repetitive material that has been omitted | IOB #1: Name = QOUT'<br>IOB #2: Name = CLKIN'<br>.<br>.<br>. |
| Horizontal ellipsis ... | Repetitive material that has been omitted | **allow block** *block_name loc1 loc2 ... locn;* |

## Online Document

The following conventions are used in this document:

| Convention | Meaning or Use | Example |
|---|---|---|
| Blue text | Cross-reference link to a location in the current document | See the section "Additional Resources" for details.<br>Refer to "Title Formats" in Chapter 1 for details. |
| Red text | Cross-reference link to a location in another document | See Figure 2-5 in the *Virtex-II Handbook*. |
| Blue, underlined text | Hyperlink to a website (URL) | Go to http://www.xilinx.com for the latest speed files. |

# ML401/ML402/ML403 Evaluation Platform

## Introduction

The ML401/ML402/ML403 evaluation platform enables designers to investigate and experiment with features of the Virtex™-4 family of FPGAs. This user guide describes features and operation of the ML401, ML402, and ML403 (ML40*x*) evaluation platforms.

### Features

- Virtex-4 FPGA:
  - ML401: XC4VLX25-FF668-10
  - ML402: XC4VSX35-FF668-10
  - ML403: XC4VFX12-FF668-10
- 64-MB DDR SDRAM, 32-bit interface running up to 266-MHz data rate
- One differential clock input pair and differential clock output pair with SMA connectors
- One 100-MHz clock oscillator (socketed) plus one extra open 3.3V clock oscillator socket
- General purpose DIP switches (ML401/ML402 platform), LEDs, and push buttons
- Expansion header with 32 single-ended I/O, 16 LVDS capable differential pairs, 14 spare I/Os shared with buttons and LEDs, power, JTAG chain expansion capability, and IIC bus expansion
- Stereo AC97 audio codec with line-in, line-out, 50-mW headphone, and microphone-in (mono) jacks
- RS-232 serial port
- 16-character x 2-line LCD display
- One 4-Kb IIC EEPROM
- VGA output:
  - ML401: 50 MHz / 24-bit video DAC
  - ML402: 140 MHz / 24-bit video DAC
  - ML403: 140 MHz / 15-bit video DAC
- PS/2 mouse and keyboard connectors
- System ACE™ CompactFlash configuration controller with Type I/II CompactFlash connector

- ZBT synchronous SRAM
  - ML401/ML402: 9 Mb on 32-bit data bus with four parity bits
  - ML403: 8 Mb on 32-bit data bus with no parity bits
- Intel StrataFlash (or compatible) linear flash chips (8 MB)
- 10/100/1000 tri-speed Ethernet PHY transceiver
- USB interface chip (Cypress CY7C67300) with host and peripheral ports
- Xilinx XC95144XL CPLD to allow linear flash chips to be used for FPGA configuration
- Xilinx XCF32P Platform Flash configuration storage device
- JTAG configuration port for use with Parallel Cable III or Parallel Cable IV cable
- Onboard power supplies for all necessary voltages
- 5V @ 3A AC adapter
- Power indicator LED

## Package Contents

- Xilinx Virtex-4 ML40*x* evaluation platform
- System ACE CompactFlash card
- Power supply
- Carrying case with anti-static foam
- Printed documentation

## Additional Information

For current information about your ML40*x* evaluation platform, visit the corresponding Web page:

- ML401: http://www.xilinx.com/ml401
- ML402: http://www.xilinx.com/ml402
- ML403: http://www.xilinx.com/ml403

The information includes:

- Current version of this user guide in PDF format
- Example design files for demonstration of Virtex-4 features and technology
- Demonstration hardware and software configuration files for the System ACE controller, Platform Flash configuration storage device, CPLD, and linear flash chips
- MicroBlaze™ and PowerPC™ 405 (ML403) EDK reference design files
- Full schematics in PDF format and ViewDraw schematic format
- PC board layout in Pads PCB format
- Gerber files in *.pho and *.pdf for the PC board (There are many free or shareware Gerber file viewers available on the internet for viewing and printing these files)
- Additional documentation, errata, frequently asked questions, and the latest news

For information about the Virtex-4 family of FPGA devices, including product highlights, data sheets, user guides, and application notes, see the Virtex-4 website at http://www.xilinx.com/virtex4. Additional information is available from the data sheets and application notes from the component manufacturers.

## Block Diagram

Figure 1 shows a block diagram of the ML40*x* evaluation platform (board).

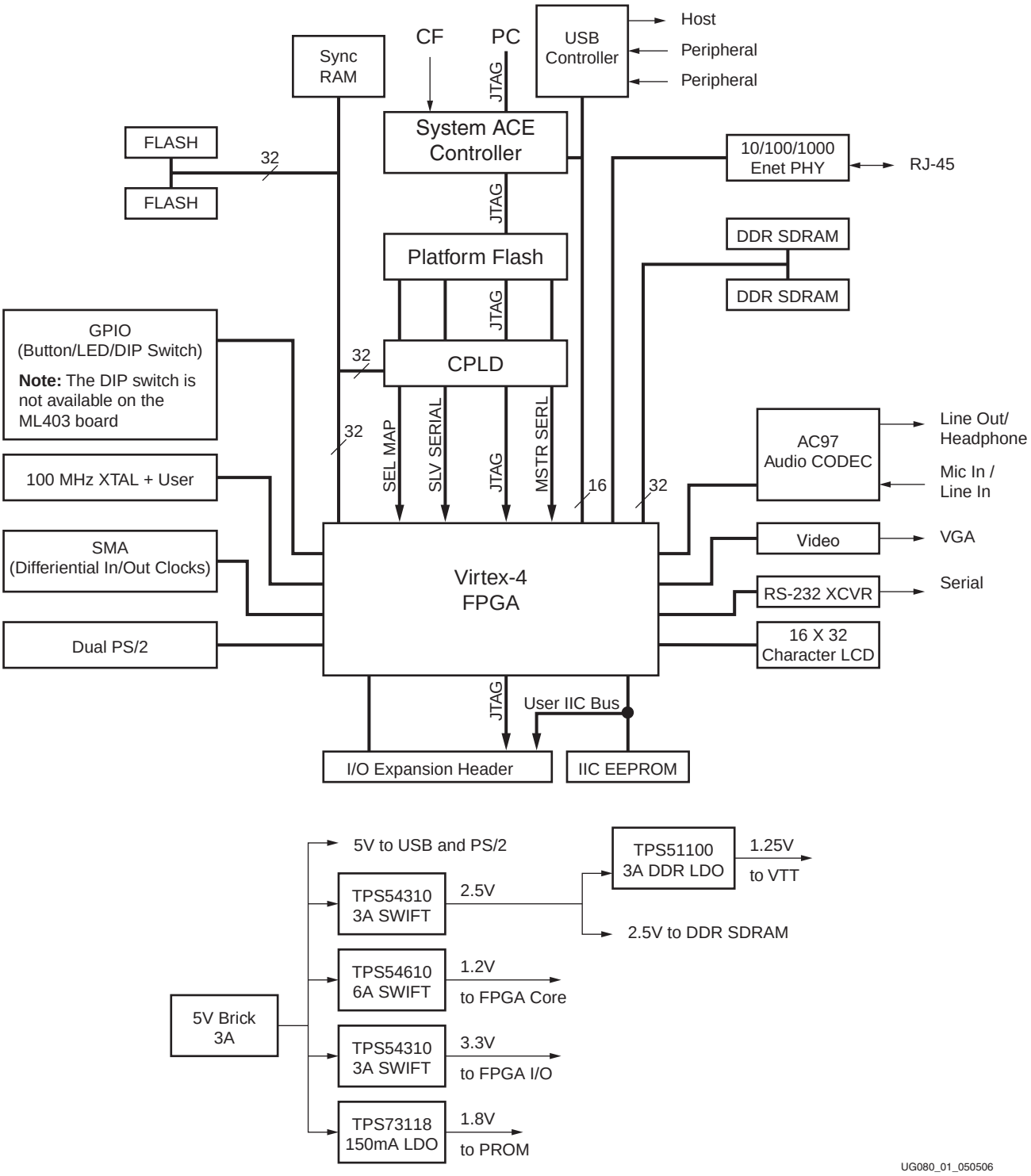



*Figure 1:* **Virtex-4 ML40*x* Evaluation Platform Block Diagram**

# Detailed Description

The ML40*x* evaluation platform (board) is shown in Figure 2 (front) and Figure 3, page 13 (back). The numbered sections on the pages following the figures contain details on each feature.

***Note:*** The ML402 and ML403 boards might differ slightly from the board shown.

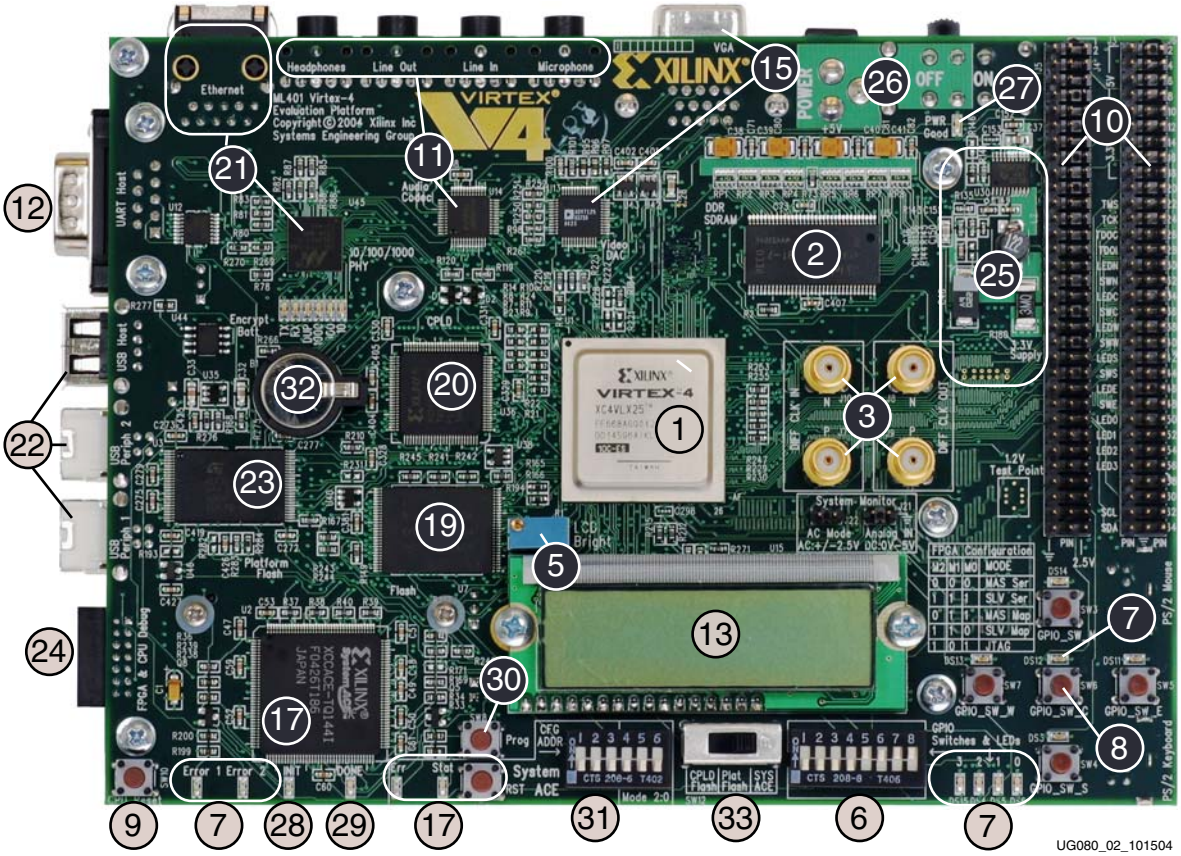



*Figure 2:* **Detailed Description of Virtex-4 ML40*x* Evaluation Platform Components (Front)**

***Note:*** The label on the CompactFlash (CF) card shipped with your board might differ slightly from the one shown.

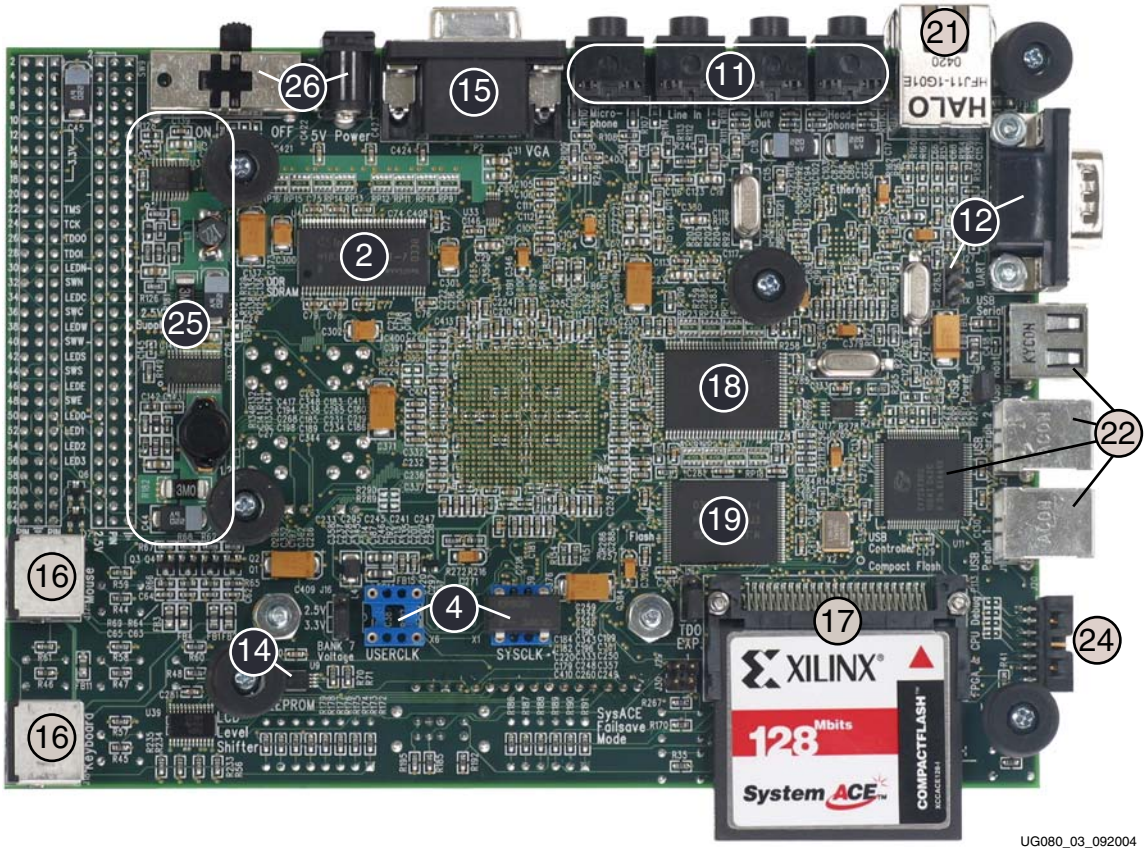



*Figure 3:* **Detailed Description of Virtex-4 ML40*x* Evaluation Platform Components (Back)**

# 1. Virtex-4 FPGA

A Xilinx Virtex-4 FPGA is installed on the evaluation platform (the board):

- ML401: XC4VLX25-FF668-10
- ML402: XC4VSX35-FF668-10
- ML403: XC4VFX12-FF668-10

## Configuration

The board supports configuration in all modes: JTAG, Master Serial, Slave Serial, Master SelectMAP, and Slave SelectMAP modes. See the "Configuration Options," page 31 section for more information.

## I/O Voltage Rails

The FPGA has 11 banks of which only the first 10 banks are used. The last bank is powered but unused. The I/O voltage applied to each bank is summarized in Table 1.

*Table 1:* **I/O Voltage Rail of FPGA Banks**

| FPGA Bank | I/O Voltage Rail |
|---|---|
| 0 | 3.3V |
| 1 | 3.3V |
| 2 | 3.3V |
| 3 | 2.5V |
| 4 | 3.3V |
| 5 | 2.5V |
| 6 | 2.5V |
| 7 | User selectable as 2.5V or 3.3V using jumper J16 |
| 8 | 3.3V |
| 9[a] | 3.3V |
| 10[a] | 3.3V (Powered but I/O pins are not used) |

a. Bank 9 and 10 are non-connected pins in the case of the ML403 with XC4VFX12-FF668.

## Digitally Controlled Impedance (DCI)

Some FPGA banks can support the DCI feature in Virtex-4 FPGAs. Support for DCI is summarized in Table 2.

*Table 2:* **DCI Capability of FPGA Bank**

| FPGA Bank | DCI Capability |
|---|---|
| 1 | Not supported. |
| 2 | Not supported. |
| 3 | Optional: User must remove resistors R234 and R235 and must install resistors R222 and R221.<br>***Note:*** Use of DCI will disable the use of GPIO LED [2] and [3]. |
| 4 | Not supported. |
| 5 | Optional: User must install resistors R224 and R225 to use DCI. In bitgen, the switch "-g DCIUpdateMode:Quiet" must also be used.<br>***Note:*** Use of DCI will disable user control of the DDR_CS_N and DDR_CKE signals. |
| 6 | Not supported. |
| 7 | Optional: User must install resistors R289 and R290.<br>***Note:*** This will disable the use of two I/O pins on the expansion connector J5 (pin 38 and 40). |
| 8 | Yes, 49.9Ω resistors are installed. |
| 9[a] | Yes, 49.9Ω resistors are installed. |
| 10[a] | Not supported. |

a. Bank 9 and 10 are non-connected pins in the case of the ML403 board with XC4VFX12-FF668.

## 2. DDR SDRAM

The board contains 64 MB of DDR SDRAM using two Infineon HYB25D256160BT-7 (or compatible) chips (U4 and U5). Each chip is 16 bits wide and together form a 32-bit data bus capable of running up to 266 MHz. All DDR SDRAM signals are terminated through 47Ω resistors to a 1.25V VTT reference voltage. The board is designed for matched length traces across all DDR control and data signals except clocks and the DDR Loop trace (see "DDR Clock Signal" and "DDR Loop Signal").

The board can support up to 256 MB of total DDR SDRAM memory if larger chips are installed. An extra address pin is present on the board to support up to 1-Gb DDR chips.

### DDR Clock Signal

The DDR clock signal is broadcast from the FPGA as a single differential pair that drives both DDR chips. The delay on the clock trace is designed to match the delay of the other DDR control and data signals. The DDR clock is also fed back to the FPGA to allow for clock deskew using Virtex-4 DCMs. The board is designed so that the DDR clock signal reaches the FPGA clock feedback pin at the same time as it arrives at the DDR chips.

### DDR Loop Signal

The DDR loop signal is a trace driven and then received back at the FPGA with a delay equal to the sum of the trace delays of the clock and DQS signals. This looped trace can be used in high-speed memory controllers to help compensate for the physical trace delays between the FPGA and DDR chips.

## 3. Differential Clock Input And Output With SMA Connectors

High-precision clock signals can be input to the FPGA using differential clock signals brought in through 50Ω SMA connectors. This allows an external function generator or other clock source to drive the differential clock inputs that directly feed the global clock input pins of the FPGA. The FPGA can be configured to present a 100Ω termination impedance.

A differential clock output from the FPGA is driven out through a second pair of SMA connectors. This allows the FPGA to drive a precision clock to an external device such as a piece of test equipment. Table 3 summarizes the differential SMA clock pin connections.

*Table 3:* **Differential SMA Clock Connections**

| Label | Clock Name | FPGA Pin |
|---|---|---|
| J10 | SMA_DIFF_CLK_IN_N | C12 |
| J7 | SMA_DIFF_CLK_IN_P | C13 |
| J8 | SMA_DIFF_CLK_OUT_N | D7 |
| J9 | SMA_DIFF_CLK_OUT_P | D8 |

## 4. Oscillator Sockets

The ML40*x* evaluation platform has two crystal oscillator sockets, each wired for standard LVTTL-type oscillators. (A 100-MHz oscillator is pre-installed in the X1 SYSCLK socket.) These connect to the FPGA clock pins as shown in Table 4. The oscillator sockets accept half-sized oscillators and are powered by the 3.3V supply.

*Table 4:* **Oscillator Socket Connections**

| Label | Clock Name | FPGA Pin |
|---|---|---|
| X1 | SYSCLK | AE14 |
| X6 | USERCLK | AD12 |

## 5. LCD Brightness and Contrast Adjustment

Turning potentiometer R1 adjusts the image contrast of the character LCD.

## 6. DIP Switches (Active-High)

Eight general purpose (active-High) DIP switches are connected to the user I/O pins of the FPGA. Table 5 summarizes these connections.

***Note:*** On the ML403 board, these DIP switches are not installed.

*Table 5:* **DIP Switches Connections (SW1)**

| SW1 | FPGA Pin |
|---|---|
| 1 | R20 |
| 2 | R19 |
| 3 | T26 |
| 4 | U26 |
| 5 | U23 |
| 6 | V23 |
| 7 | U25 |
| 8 | U24 |

## 7. User and Error LEDs (Active-High)

There are a total of 11* active-High LEDs directly controllable by the FPGA:

- Four green LEDs are general purpose LEDs arranged in a row
- Five green LEDs are positioned next to the North-East-South-West-Center oriented push buttons (only the *center* one is cited in Figure 2, page 12)
- Two* red LEDs are intended to be used for signaling error conditions, such as bus errors, but can be used for any other purpose

***Note:*** *On the ML403 board, the Error 2 LED is not installed.

Table 6 summarizes the LED definitions and connections.

*Table 6:* **User and Error LED Connections**

| Reference Designator | Label/Definition | Color | FPGA Pin |
|---|---|---|---|
| DS14 | LED North | Green | E2 |
| DS11 | LED East | Green | E10 |
| DS3 | LED South | Green | A5 |
| DS13 | LED West | Green | F9 |
| DS12 | LED Center | Green | C6 |
| DS15 | GPIO LED 0 | Green | G5 |
| DS4 | GPIO LED 1 | Green | G6 |
| DS5 | GPIO LED 2 | Green | A11 |
| DS6 | GPIO LED 3 | Green | A12 |
| DS205 | Error 1 | Red | V6 |
| DS206* | Error 2 | Red | L24 |

***Note:*** *On the ML403 board, the Error 2 LED is not installed.

## 8. User Push Buttons (Active-High)

Five active-High user push buttons are available for general purpose usage and are arranged in a North-East-South-West-Center orientation (only the *center* one is cited in Figure 2, page 12). Table 7 summarizes the user push button connections.

*Table 7:* **User Push Button Connections**

| Reference Designator | Label/Definition | FPGA Pin |
|---|---|---|
| SW3 | GPIO Switch North | E7 |
| SW5 | GPIO Switch East | F10 |
| SW4 | GPIO Switch South | A6 |
| SW7 | GPIO Switch West | E9 |
| SW6 | GPIO Switch Center | B6 |

## 9. CPU Reset Button (Active-Low)

The CPU reset button is an active-Low push button intended to be used as a system or user reset button. This button is wired only to an FPGA I/O pin, so it can also be used as a general purpose button (see Table 8).

*Table 8:* **CPU Reset Connections**

| Reference Designator | Label/Definition | FPGA Pin |
|---|---|---|
| SW10 | FPGA CPU RESET | D6 |

# 10. Expansion Headers

The board contains expansion headers for easy expansion or adaptation of the board for other applications. The expansion connectors use standard 0.1-inch headers. The expansion connectors contain connections to single-ended and differential FPGA I/Os, ground, 2.5V/3.3V/5V power, JTAG chain, and the IIC bus.

## Differential Expansion I/O Connectors

Header J5 contains 16 pairs of differential signal connections to the FPGA I/Os. This permits the signals on this connector to carry high-speed differential signals such as LVDS data. All differential signals are routed with 100Ω differential trace impedance. Matched length traces are used across all differential signals; consequently, these signals connect to the FPGA I/O and can also be used as independent single-ended nets. The $V_{CCIO}$ of these signals can be set to 2.5V or 3.3V by setting jumper J16. Table 9 summarizes the differential connections on this expansion I/O connector.

*Table 9:* **Expansion I/O Differential Connections (J5)**

| Header Pin (Diff Pair Pos) | Header Pin (Diff Pair Neg) | Label (Diff Pair Pos) | Label (Diff Pair Neg) | FPGA Pin (Diff Pair Pos) | FPGA Pin (Diff Pair Neg) |
|---|---|---|---|---|---|
| J5, Pin 4 | J5, Pin 2 | HDR2_4 | HDR2_2 | AA18 | Y18 |
| J5, Pin 8 | J5, Pin 6 | HDR2_28 | HDR2_26 | Y19 | W19 |
| J5, Pin 12 | J5, Pin 10 | HDR2_20 | HDR2_18 | Y20 | Y21 |
| J5, Pin 16 | J5, Pin 14 | HDR2_12 | HDR2_10 | W23 | W24 |
| J5, Pin 20 | J5, Pin 18 | HDR2_8 | HDR2_6 | Y22 | Y23 |
| J5, Pin 24 | J5, Pin 22 | HDR2_60 | HDR2_58 | AA19 | AA20 |
| J5, Pin 28 | J5, Pin 26 | HDR2_56 | HDR2_54 | Y17 | AA17 |
| J5, Pin 32 | J5, Pin 30 | HDR2_52 | HDR2_50 | AB20 | AC20 |
| J5, Pin 36 | J5, Pin 34 | HDR2_36 | HDR2_34 | AE21 | AD21 |
| J5, Pin 40 | J5, Pin 38 | HDR2_16 | HDR2_14 | AE20 | AD20 |
| J5, Pin 44 | J5, Pin 42 | HDR2_64 | HDR2_62 | AD19 | AC19 |
| J5, Pin 48 | J5, Pin 46 | HDR2_48 | HDR2_46 | AC18 | AB18 |
| J5, Pin 52 | J5, Pin 50 | HDR2_24 | HDR2_22 | AF23 | AE23 |
| J5, Pin 56 | J5, Pin 54 | HDR2_44 | HDR2_42 | AF21 | AF22 |
| J5, Pin 60 | J5, Pin 58 | HDR2_32 | HDR2_30 | AF19 | AF20 |
| J5, Pin 64 | J5, Pin 62 | HDR2_40 | HDR2_38 | AF18 | AE18 |

## Single-Ended Expansion I/O Connectors

Header J6 contains 32 single-ended signal connections to the FPGA I/Os. This permits the signals on this connector to carry high-speed single-ended data. All single-ended signals on connector J6 are matched length traces. The $V_{CCIO}$ of these signals can be set to 2.5V or 3.3V by setting jumper J16. Table 10 (spans onto next page) summarizes the single-ended connections on this expansion I/O connector.

*Table 10:* **Expansion I/O Single-Ended Connections (J6)**

| Header Pin | Label | FPGA Pin |
|---|---|---|
| J6, Pin 2 | HDR1_28 | AA24 |
| J6, Pin 4 | HDR1_42 | V20 |
| J6, Pin 6 | HDR1_36 | AC25 |
| J6, Pin 8 | HDR1_2 | AC24 |
| J6, Pin 10 | HDR1_52 | W25 |
| J6, Pin 12 | HDR1_32 | AB24 |
| J6, Pin 14 | HDR1_26 | Y24 |
| J6, Pin 16 | HDR1_12 | AB23 |
| J6, Pin 18 | HDR1_50 | W26 |
| J6, Pin 20 | HDR1_38 | Y26 |
| J6, Pin 22 | HDR1_40 | Y25 |
| J6, Pin 24 | HDR1_22 | AA26 |
| J6, Pin 26 | HDR1_10 | AA23 |
| J6, Pin 28 | HDR1_60 | AC21 |
| J6, Pin 30 | HDR1_24 | AB26 |
| J6, Pin 32 | HDR1_4 | AC23 |
| J6, Pin 34 | HDR1_30 | AB25 |
| J6, Pin 36 | HDR1_6 | AD23 |
| J6, Pin 38 | HDR1_34 | AC26 |
| J6, Pin 40 | HDR1_18 | AD26 |
| J6, Pin 42 | HDR1_16 | AC22 |
| J6, Pin 44 | HDR1_54 | V22 |
| J6, Pin 46 | HDR1_56 | V21 |
| J6, Pin 48 | HDR1_46 | W22 |
| J6, Pin 50 | HDR1_20 | AD25 |
| J6, Pin 52 | HDR1_14 | AB22 |
| J6, Pin 54 | HDR1_48 | W21 |
| J6, Pin 56 | HDR1_44 | W20 |

*Table 10:* **Expansion I/O Single-Ended Connections (J6) *(Continued)***

| Header Pin | Label | FPGA Pin |
|---|---|---|
| J6, Pin 58 | HDR1_58 | AB21 |
| J6, Pin 60 | HDR1_8 | AD22 |
| J6, Pin 62 | HDR1_62 | AE24 |
| J6, Pin 64 | HDR1_64 | AF24 |

## Other Expansion I/O Connectors

In addition to the high-speed I/O paths, additional I/O signals and power connections are available to support expansion cards plugged into ML40*x* board (see Table 11, page 23). The 14 I/O pins from the general purpose buttons and LEDs on the board are connected to expansion connector J3. This arrangement permits additional I/Os to be connected to the expansion connector if the buttons and LEDs are not used. It also allows the expansion card to utilize the buttons and LEDs on the board.

The expansion connector also allows the board's JTAG chain to be extended onto the expansion card by setting jumper J26 accordingly.

The IIC bus on the board is also extended onto the expansion connector to allow additional IIC devices to be bused together. If the expansion IIC bus is to be utilized, the user must have the IIC pull-up resistors present on the expansion card. Bidirectional level shifting transistors allow the expansion card to utilize 2.5V to 5V signaling on the IIC bus.

Power supply connections to the expansion connectors provide ground, 2.5V, 3.3V, and 5V power pins. If the expansion card draws significant power from the ML40*x* board, the user must ensure that the total power draw can be supplied by the board.

The ML40*x* expansion connector is backward compatible with the expansion connectors on the ML320, ML321, and ML323 boards, thereby allowing their daughter cards to be used with the ML40*x* evaluation platform. Table 11, page 23 summarizes the additional expansion I/O connections.

*Table 11:* **Additional Expansion I/O Connections**

| Header Pin | Label | FPGA Pin | Description |
|---|---|---|---|
| J3, Pin 1 | VCC5 | N/A | 5V Power Supply |
| J3, Pin 2 | VCC5 | N/A | 5V Power Supply |
| J3, Pin 3 | VCC5 | N/A | 5V Power Supply |
| J3, Pin 4 | VCC5 | N/A | 5V Power Supply |
| J3, Pin 5 | NC | N/A | Not Connected |
| J3, Pin 6 | VCC3V3 | N/A | 3.3V Power Supply |
| J3, Pin 7 | VCC3V3 | N/A | 3.3V Power Supply |
| J3, Pin 8 | VCC3V3 | N/A | 3.3V Power Supply |
| J3, Pin 9 | VCC3V3 | N/A | 3.3V Power Supply |
| J3, Pin 10 | NC | N/A | Not Connected |
| J3, Pin 11 | TMS | N/A | Expansion TMS |
| J3, Pin 12 | TCK | N/A | Expansion TCK |
| J3, Pin 13 | TDO | N/A | Expansion TDO |
| J3, Pin 14 | TDI | N/A | Expansion TDI |
| J3, Pin 15 | LED North | E2 | LED North |
| J3, Pin 16 | GPIO Switch North | E7 | GPIO Switch North |
| J3, Pin 17 | LED Center | C6 | LED Center |
| J3, Pin 18 | GPIO Switch Center | B6 | GPIO Switch Center |
| J3, Pin 19 | LED West | F9 | LED West |
| J3, Pin 20 | GPIO Switch West | E9 | GPIO Switch West |
| J3, Pin 21 | LED South | A5 | LED South |
| J3, Pin 22 | GPIO Switch South | A6 | GPIO Switch South |
| J3, Pin 23 | LED East | E10 | LED East |
| J3, Pin 24 | GPIO Switch East | F10 | GPIO Switch East |
| J3, Pin 25 | GPIO LED 0 | G5 | GPIO LED 0 |
| J3, Pin 26 | GPIO LED 1 | G6 | GPIO LED 1 |
| J3, Pin 27 | GPIO LED 2 | A11 | GPIO LED 2 |
| J3, Pin 28 | GPIO LED 3 | A12 | GPIO LED 3 |
| J3, Pin 29 | NC | N/A | Not Connected |
| J3, Pin 30 | NC | N/A | Not Connected |
| J3, Pin 31 | EXP_IIC_SCL | A17 | Expansion IIC SCL |
| J3, Pin 32 | EXP_IIC_SDA | B17 | Expansion IIC SDA |

## 11. Stereo AC97 Audio Codec

The ML40*x* board has an AC97 audio codec (U14) to permit audio processing. The National Semiconductor LM4550 Audio Codec supports stereo 16-bit audio with up to 48-kHz sampling. The sampling rate for record and playback can be different.

***Note:*** The reset for the AC97 codec is shared with the reset signal for the flash memory chips and is designed to be asserted at power-on or upon system reset.

Separate audio jacks are provided for Microphone, Line In, Line Out, and Headphone. All jacks are stereo except for Microphone. The Headphone jack is driven by the audio codec's internal 50-mW amplifier. Table 12 summarizes the audio jacks.

*Table 12:* **ML40*x* Audio Jacks**

| Reference Designator | Function | Stereo/Mono |
|---|---|---|
| J11 | Microphone - In | Mono |
| J12 | Analog Line - In | Stereo |
| J13 | Analog Line - Out | Stereo |
| J14 | Headphone - Out | Stereo |

## 12. RS-232 Serial Port

The ML40*x* board contains one male DB-9 RS-232 serial port allowing the FPGA to communicate serial data with another device. The serial port is wired as a host (DCE) device. Therefore, a null modem cable is normally required to connect the board to the serial port on a PC. The serial port is designed to operate up to 115200 Bd. An interface chip is used to shift the voltage level between FPGA and RS-232 signals.

***Note:*** The FPGA is only connected to the TX and RX data pins on the serial port. Therefore, other RS-232 signals, including hardware flow control signals, are not used. Flow control should be disabled when communicating with a PC.

A secondary serial interface is available by using header J27 to support debug of the USB controller chip. Header J27 brings out RS-232 voltage level signals for ground, TX data, and RX data.

## 13. 16-Character x 2-Line LCD

The ML40*x* board has a 16-character x 2-line LCD (Lumex LCM-S01602DTR/M) on the board to display text information. Potentiometer R1 adjusts the contrast of the LCD. The data interface to the LCD is connected to the FPGA to support 4-bit mode only. A level translator chip is used to shift the voltage level between the FPGA and the LCD.

***Caution!*** Care should be taken not to scratch or damage the surface of the LCD window. The protective layer of tape on the top of the screen should be left on for added protection of the screen's surface.

## 14. IIC Bus with 4-Kb EEPROM

An IIC EEPROM (Microchip Technology 24LC04B-I/ST) is provided on the ML40*x* board to store non-volatile data such as an Ethernet MAC address. The EEPROM write protect is tied off on the board to disable its hardware write protect. The IIC bus uses 2.5V signaling and can operate at up to 400 kHz. IIC bus pull-up resistors are provided on the board.

The IIC bus is extended to the expansion connector so that the user may add additional IIC devices and share the IIC controller in the FPGA. If the expansion IIC bus is to be utilized, the user must have additional IIC pull-up resistors present on the expansion card. Bidirectional level shifting transistors allow the expansion card to utilize 2.5V to 5V signaling on IIC.

## 15. VGA Output

The VGA output port (P2) supports an external video monitor. Table 13 lists each board and its corresponding video DAC chip.

*Table 13:* **Video DAC Connections**

| Board | Speed | Description | Video Monitor |
|---|---|---|---|
| ML401 | 50 MHz | 24-bit video data bus connected to FPGA | Analog Devices ADV7125KST50 |
| ML402 | 140 MHz | | Analog Devices ADV7125KST140 |
| ML403 | | 15-bit video data bus connected to FPGA | |

***Note:*** Due to the reduced pin count on ML403 board's XC4VFX12 FPGA, only the five most significant bits of digital RGB data are connected to the video DAC. The three least significant bits of digital RGB data are pulled Low.

## 16. PS/2 Mouse and Keyboard Ports

The ML40*x* evaluation platform contains two PS/2 ports: one for a mouse (J17) and the other for a keyboard (J18). Bidirectional level shifting transistors allow the FPGA's 2.5V I/O to interface with the 5V I/O of the PS/2 ports. The PS/2 ports on the board are powered directly by the main 5V power jack, which also powers the rest of the board.

***Caution!*** Care must be taken to ensure that the power load of any attached PS/2 devices does not overload the AC adapter.

## 17. System ACE and CompactFlash Connector

The Xilinx System ACE CompactFlash (CF) configuration controller allows a Type I or Type II CompactFlash card to program the FPGA through the JTAG port. Both hardware and software data can be downloaded through the JTAG port. The System ACE controller supports up to eight configuration images on a single CompactFlash card. The configuration address switches allow the user to choose which of the eight configuration images to use.

System ACE error and status LEDs indicate the operational state of the System ACE controller:

- A blinking red error LED indicates that no CompactFlash card is present
- A solid red error LED indicates an error condition during configuration
- A blinking green status LED indicates a configuration operation is ongoing
- A solid green status LED indicates a successful download

Every time a CompactFlash card is inserted into the System ACE socket, a configuration operation is initiated. Pressing the System ACE reset button re-programs the FPGA.

The board also features a System ACE *failsafe* mode. In this mode, if the System ACE controller detects a failed configuration attempt, it automatically reboots back to a predefined configuration image. The failsafe mode is enabled by inserting two jumpers across J29 and J30 (in horizontal or vertical orientation).

> ***Caution!*** Use caution when inserting a CompactFlash card with exposed metallic surfaces. Improper insertion can cause a short with the traces or components on the board.

The System ACE MPU port is connected to the FPGA. This connection allows the FPGA to use the System ACE controller to reconfigure the system or access the CompactFlash card as a generic FAT file system. The data bus for the System ACE MPU port is shared with the USB controller.

For configuration through the System ACE controller, the configuration selector switch (SW12) must be set to the SYS ACE position.

## 18. ZBT Synchronous SRAM

The ZBT synchronous SRAM (Cypress CY7C1354B or compatible) provides high-speed, low-latency external memory to the FPGA. The memory is organized as 256K x 36 bits. This organization provides for a 32-bit data bus with support for four parity bits. On ML403, the parity bits are not accessible.

***Note:*** The SRAM and FLASH memory share the same data bus.

## 19. Linear Flash Chips

Two 32-Mb linear flash devices (Micron MT28F320J3RG-11 ET) are installed on the board for a total of 8 MB of flash memory. These flash memory chips are Intel StrataFlash compatible. This memory provides non-volatile storage of data, software, or bitstreams. Each flash chip is 16 bits wide and together forms a 32-bit data bus that is shared with SRAM. In conjunction with a CPLD, the flash memory can also be used to program the FPGA.

***Note:*** The reset for the AC97 Codec is shared with the reset signal for the flash memory chips and is designed to be asserted at power-on or upon system reset.

## 20. Xilinx XC95144XL CPLD

A Xilinx XC95144XL CPLD is connected to the flash memory and the FPGA configuration signals. This CPLD connection supports applications where flash memory programs the FPGA. The CPLD is programmed from the main JTAG chain of the board. The CPLD is wired so that it can support master or slave configuration in serial or parallel (SelectMAP) modes. For FPGA configuration via the CPLD and flash, the configuration selector switch (SW12) must be set to the CPLD Flash position. See the "Configuration Options," page 31 section for more information.

## 21. 10/100/1000 Tri-Speed Ethernet PHY

The ML40*x* evaluation platform contains a Marvell Alaska PHY device (88E1111) operating at 10/100/1000 Mb/s. The board supports MII, GMII, and RGMII interface modes with the FPGA. The PHY is connected to a Halo HFJ11-1G01E RJ-45 connector with built-in magnetics. A 25-MHz crystal supplies the clock signal to the PHY. The PHY is configured to default at power-on or reset to the following settings (See Table 14). These settings may be overwritten via software.

*Table 14:* **Board Connections for PHY Configuration Pins**

| Config Pin | Connection on Board | Bit[2] Definition and Value | Bit[1] Definition and Value | Bit[0] Definition and Value |
|---|---|---|---|---|
| CONFIG0 | Ground | PHYADR[2] = 0 | PHYADR[1] = 0 | PHYADR[0] = 0 |
| CONFIG1 | Ground | ENA_PAUSE = 0 | PHYADR[4] = 0 | PHYADR[3] = 0 |
| CONFIG2 | $V_{CC}$ 2.5V | ANEG[3] = 1 | ANEG[2] = 1 | ANEG[1] = 1 |
| CONFIG3 | $V_{CC}$ 2.5V | ANEG[0] = 1 | ENA_XC = 1 | DIS_125 = 1 |
| CONFIG4 | $V_{CC}$ 2.5V | HWCFG_MODE[2] = 1 | HWCFG_MODE[1] = 1 | HWCFG_MODE[0] = 1 |
| CONFIG5 | $V_{CC}$ 2.5V | DIS_FC = 1 | DIS_SLEEP = 1 | HWCFG_MODE[3] = 1 |
| CONFIG6 | LED_RX | SEL_BDT = 0 | INT_POL = 1 | 75/50Ω = 0 |

## 22. USB Controller with Host and Peripheral Ports

A Cypress CY7C67300 embedded USB host controller provides USB connectivity for the board. The USB controller supports host and peripheral modes of operation. The USB controller has two serial interface engines (SIE) that can be used independently. SIE1 is connected to the USB Host 1 connector (J19) and the USB Peripheral 1 connector (J2). SIE2 is connected only to the USB Peripheral 2 connector.

***Note:*** When using SIE1, the port can only be configured at boot-up to use either the host or peripheral connector, but not both at the same time.

The USB controller has an internal microprocessor to assist in processing USB commands. The firmware for this processor can be stored in its own dedicated IIC EEPROM (U17) or can be downloaded from a host computer via a peripheral connector. The USB controller's serial port is connected to J27 through an RS-232 transceiver to assist with debug.

## 23. Xilinx XCF32P Platform Flash Configuration Storage Device

Xilinx XCF32P Platform Flash configuration storage device offers a convenient and easy-to-use configuration solution for the FPGA. The Platform Flash memory holds up to four separate configuration images (two images on the ML402 board) that can be accessed through the configuration address switches. To use the Platform Flash memory to configure the FPGA, the configuration selector switch (SW12) must be set to the Plat Flash position.

The Platform Flash memory can program the FPGA by using the master or slave configuration in serial or parallel (SelectMap) modes. The Platform Flash memory is programmed using Xilinx iMPACT software through the board's JTAG chain. See the "Configuration Options," page 31 section for more information.

## 24. JTAG Configuration Port

The JTAG configuration port for the board (J20) allows for device programming and FPGA debug. The JTAG port supports the Xilinx Parallel Cable III or Parallel Cable IV products. Third-party configuration products might also be available. The JTAG chain can also be extended to an expansion board by setting jumper J26 accordingly. See the "Configuration Options," page 31 section for more information.

## 25. Onboard Power Supplies

Power supply circuitry on the board generates 1.2V, 1.25V, 1.8V, 2.5V, and 3.3V voltages to power the components on the board. The 1.2V, 2.5V, and 3.3V supplies are driven by switching power regulators. When these three switching regulators report they are running at their nominal voltages, the PWR Good LED is turned on.

The diagram in Figure 4 shows the power supply architecture and maximum current handling on each supply. The typical operating currents are significantly below the maximum capable. The ML40*x* board is normally shipped with a 15W power supply which should be sufficient for most applications.

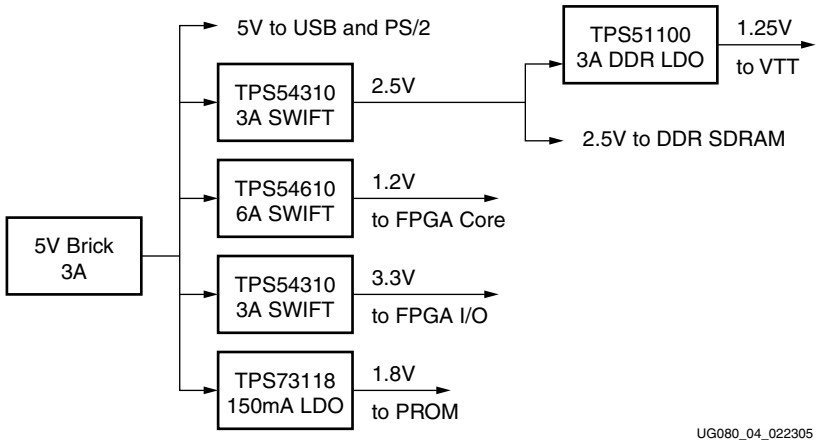



*Figure 4:* **Power Supply Diagram**

## 26. AC Adapter and Input Power Switch/Jack

The ML40*x* board ships with a 15W (5V @ 3A) AC adapter. The power connector is a 2.1 mm x 5.5 mm barrel type plug (center positive). For applications requiring additional power, such as the use of expansion cards drawing significant power, a larger AC adapter might be required. If a different AC adapter is used, its load regulation should be less than 10% or better than ±10%. The power switch turns the board on and off by controlling the supply of 5V to the board.

## 27. Power Indicator LED

The PWR Good LED lights when the 1.2V, 2.5V, and 3.3V power supplies are all at their nominal operating conditions. If the PWR Good LED is off, blinking, or glowing lightly, this indicates a fault condition, such as a short or overload condition, might exist.

## 28. INIT LED

The INIT LED lights upon power-up to indicate that the FPGA has successfully powered up and completed its internal power-on process.

## 29. DONE LED

The DONE LED indicates the status of the DONE pin on the FPGA. It should be lighted when the FPGA is successfully configured.

## 30. Program Switch

This switch grounds the FPGA's Prog pin when pressed. This action clears the FPGA.

## 31. Configuration Address and Mode DIP Switches

This 6-position DIP switch controls the configuration address and FPGA configuration mode.

The three leftmost switches choose one of eight possible configuration addresses. These three DIP switches provide the System ACE controller and the CPLD the possibility of using up to eight different configuration images as set by these three switches. The Platform Flash memory supports up to four different images.

The three rightmost DIP switches set the FPGA configuration mode pins M2, M1, and M0 as shown in Table 15.

*Table 15:* **Configuration Mode DIP Switch Settings**

| M2 | M1 | M0 | Mode |
|---|---|---|---|
| 0 | 0 | 0 | Master Serial |
| 1 | 1 | 1 | Slave Serial |
| 0 | 1 | 1 | Master Parallel (SelectMAP) |
| 1 | 1 | 0 | Slave Parallel (SelectMAP) |
| 1 | 0 | 1 | JTAG |

## 32. Encryption Key Battery

An onboard battery holder is connected to the $V_{BATT}$ pin of the FPGA to hold the encryption key for the FPGA. A 12-mm lithium coin battery (3V), such as Panasonic part numbers BR1216, CR1216, and BR1225, or any other appropriate 12-mm lithium coin battery (3V) can be used.

## 33. Configuration Source Selector Switch

The configuration source selector switch (SW12) selects between System ACE, Platform Flash, and linear flash/CPLD methods of programming the FPGA. Whichever method is selected to program the FPGA, make sure the FPGA configuration mode switches are set appropriately for the desired method of configuration. The PC4 connector allows JTAG download and debug of the board regardless of the setting of the configuration source selector switch.

# Configuration Options

The FPGA on the ML40*x* evaluation platform can be configured by four major devices:

- Parallel Cable IV cable (JTAG)
- System ACE controller (JTAG)
- Platform Flash memory
- Linear flash + CPLD

The following section provides an overview of the possible ways the board can be configured.

## JTAG (Parallel Cable IV Cable and System ACE Controller)

The FPGA, Platform Flash memory, and CPLD can be configured through the JTAG port. The JTAG chain of the board is illustrated in Figure 5.

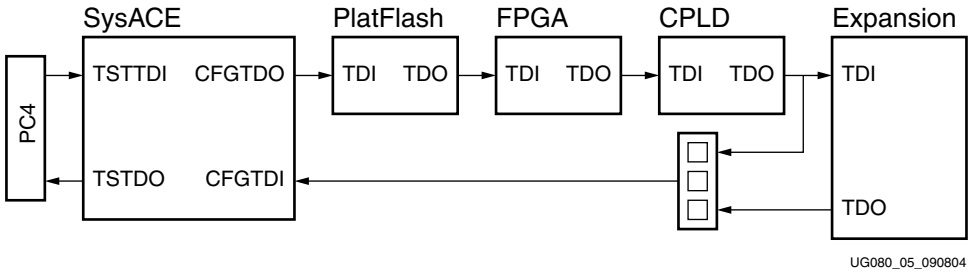



*Figure 5:* **JTAG Chain**

The chain starts at the PC4 connector and goes through the System ACE controller, the Platform Flash memory, the FPGA, the CPLD, and an optional extension of the chain to the expansion card. Jumper J26 determines if the JTAG chain should be extended to the expansion card.

The JTAG chain can be used to program the FPGA and access the FPGA for hardware and software debug. The JTAG chain is also used to program the Platform Flash memory and the CPLD.

The PC4 JTAG connection to the JTAG chain allows a host PC to download bitstreams to the FPGA using the iMPACT software tool. PC4 also allows debug tools such as the ChipScope™ Pro Analyzer or a software debugger to access the FPGA.

The System ACE controller can also program the FPGA through the JTAG port. Using an inserted CompactFlash card or Microdrive storage device, configuration information can be stored and played out to the FPGA. The System ACE controller supports up to eight configuration images that can selected using the three configuration address DIP switches. Under FPGA control, the System ACE chip can be instructed to reconfigure to any of the eight configuration images.

The configuration source selector switch should be in the SYS ACE setting if the use of the System ACE controller is desired.

When set correctly, the System ACE controller programs the FPGA upon power-up if a CompactFlash card is present or whenever a CompactFlash card is inserted. Pressing the System ACE reset button also causes the System ACE controller to program the FPGA if a CompactFlash card is present.

## Platform Flash Memory

The Platform Flash memory can also be used to program the FPGA. The Platform Flash memory can hold up to four configuration images, which are selectable by the two least significant bits of the configuration address DIP switches.

***Note:*** ML402 Platform Flash memory can hold two configuration images, which are selectable by the least significant bit of the configuration address DIP switches.

The board is wired so the Platform Flash memory can download bitstreams in Master Serial, Slave Serial, Master SelectMAP (parallel), or Slave SelectMAP (parallel) modes. Using the iMPACT tool to program the Platform Flash memory, the user has the option to select which of the four modes to use for programming the FPGA. The configuration mode DIP switches on the board must be set to match the programming method being used by the Platform Flash memory.

The configuration source selector switch should be in the Plat Flash setting if the use of Platform Flash memory is desired.

When set correctly, the Platform Flash memory programs the FPGA upon power-up or whenever the Prog button is pressed.

## Linear Flash + CPLD

Data stored in the linear flash can be read by the CPLD and used to program the FPGA. Depending on the logic design in the CPLD, up to eight configuration images can theoretically be supported.

***Note:*** Note: ML402 linear flash can hold up to four configuration images.

The board is wired so the CPLD can download bitstreams via Master Serial, Slave Serial, Master SelectMAP (parallel), or Slave SelectMAP (parallel) modes. The configuration mode DIP switches on the board must be set to match the programming method being used by the CPLD.

The configuration source selector switch should be in the CPLD Flash setting if the use of CPLD + Platform Flash is desired.

When set correctly, the CPLD programs the FPGA upon power-up or whenever the Prog button is pressed.

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